Territorial Patterns of Open E-Government

Evidence from Chilean Municipalities

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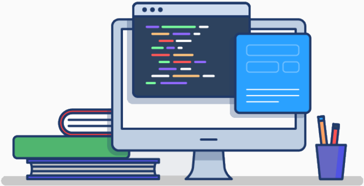


Introduction

Introduction

Our main question is: **What factors determine the development of open e-government in Chilean municipalities?**

We have constructed an index that combines elements of e-government with transparency indicators for all Chilean municipalities ($n = 345$) between 2019 and 2021.

Then, we evaluated digital development at the local using **geospatial econometric models**.

Empirical Expectations

The literature identifies a series of factors as determinants of the success of local e-government. They include elements related to the availability of technological infrastructure (Alcaide-Muñoz et al., 2014; Lowatcharin and Menifield, 2015); the characteristics or size of the population (Dias and Costa, 2013; Maciel et al., 2016; Tejedo-Romero et al., 2022); organisational factors or local administrative capacity (Andrews and Entwistle, 2015; Andrews et al., 2013; Manoharan, 2013b; Norris and Moon, 2005; Puron-Cid and Rodríguez-Bolívar, 2018); and political factors (Sicáková-Beblavá et al., 2016; Tejedo-Romero and Ferraz Esteves de Araujo, 2018).

Our empirical expectations focus on the first three dimensions related to: (i) **infrastructure**; (ii) characteristics of the population and, in particular, its **socioeconomic level**; and (iii) local **administrative capacity**.

Infrastructure

There is no consensus about the magnitude of the influence of infrastructure on digital development and transparency. Sicáková-Beblavá et al. (2016) found that it is not possible to confirm that greater Internet access leads to a higher level of government transparency. Lowatcharin and Menifield (2015) also reached a similar conclusion.

Even so, our empirical expectation is to find a positive relationship between infrastructure and the development of open e-government in Chilean municipalities (González-Bustamante et al., 2020). Therefore, our first hypothesis is:

- **Infrastructure Hypothesis**. The number of fixed Internet connections in a municipal district increases the municipality's development of open e-government.

Socioeconomic Level

In the case of the population's characteristics and their effect on the development of open e-government at the local level, the variables highlighted by the literature include age range and socioeconomic level. On the socioeconomic level, a study by Dias and Costa (2013), for example, concluded that the population's income level explains the demand for access to information.

We focus on the aggregate socioeconomic level measured inversely using monetary poverty indicators. Consequently, our second hypothesis is:

- **Socioeconomic Level Hypothesis**. A municipal district's level of monetary poverty reduces the municipality's development of open e-government.

Financial Resources

Just as the population's income is an important variable for evaluating the development of open e-government, the municipal government's own revenues should also be important (Dias and Costa, 2013; González-Bustamante et al., 2020).

We assert that the greater a municipal government's autonomous financing, the higher the level of open e-government will be. There will, therefore, be a difference with municipalities that do not have sufficient sources of revenues and, probably, have weaker organisational capacities. Consequently, our empirical expectation is as follows:

- **Financial Resources Hypothesis**. A municipality's own revenues increase its development of open e-government.

Administrative Capacity

We also consider the technical capabilities of municipal personnel as a determinant of the development of open e-government. Chapman (2017), for example, identifies a municipal government's professionalisation as explaining its level of adoption of e-government and innovation. Similarly, Manoharan (2013a) studied the institutional variables of US counties as predictors of the adoption of e-government. Therefore, our fourth hypothesis is:

- **Administrative Capacity Hypothesis**. The level of professionalisation of municipal personnel increases the municipality's development of open e-government.

Empirical Strategy

Index of Open E-Government

We started by using the **e-services model** of Esteves (2005), which contains different items grouped into five dimensions, to evaluate government websites (Fath-Allah et al., 2017).

We applied the model to Chile's 345 municipalities. To this end, we carried out a binary measurement for each item and an aggregation, derived from the original formula of Esteves (2005), which takes into account the weights theoretically associated with the level of sophistication or digital maturity of each phase for the *i-th* municipalities:

$$Y_i = f_{1[i]} \times (0.25) + f_{2[i]} \times (0.50) + f_{3_{[i]}} \times (0.75) + f_{4[i]} \times (1.00) + f_{5[i]} \times (1.25) \quad (1)$$

Municipal E-Services Model

	Phase	Item
f_1	Presence	Forms (downloadable documents) Municipal newsletter Online map
f_2	Urban information	Urban map Transport information
f_3	Interaction	Municipal social networks Municipal telephone Mobile
f_4	Transaction	Online official procedures Follow-up Digital certificates Register of residents Online payment
f_5	E-democracy	Citizen participation

Some items in the original model, such as the presence of a **search engine** or the option of **personalising the interface** with the website, have been omitted so as to give priority to the incorporation of more important elements that are now of daily use, such as **digital social networks**.

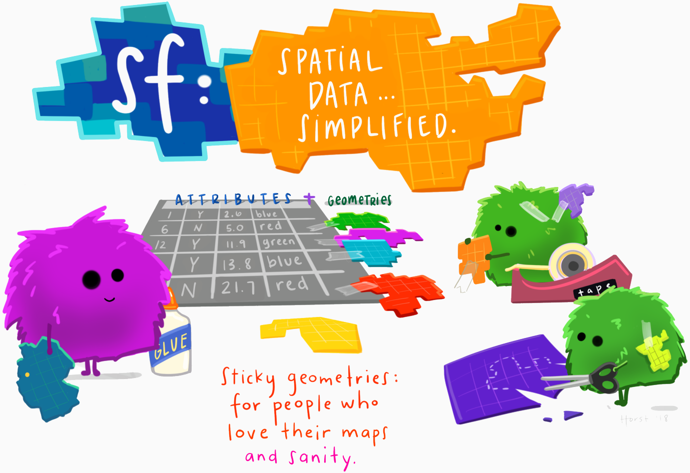
Index of Open E-Government

We carried out measurements of municipal e-government, obtaining an estimate of the EGi. **We then expanded the EGi by incorporating transparency indicators**.

We used the requests for access to public information (**Freedom of Information Act, FOIA**) to construct an indicator of the average number of working days that each municipal government took to respond to requests. We used weights equivalent to f_4 for responses within the extended legal period and f_5 for responses within the strict period of 20 days.

Our aggregate OEGi has a Cronbach's α of 0.681 for all Chile's municipalities (95% CI $[0.635, 0.719]$). In the regions with over one million inhabitants, the indicator increases to 0.713 (95% CI $[0.658, 0.758]$). We carried out multiple imputations below 5% of cases.

Independent Variables



Independent Variables

We integrated the index with **geospatial** information and local government indicators compiled using the following open data and public information:

- Geospatial shapefiles (IDE-Chile and SUBDERE, 2018, 2020)
- Number of fixed Internet connections (SUBTEL, 2022)
- Rate of monetary poverty with a small area estimation (SAE) (DOS-MDSF and ECLAC, 2021)
- Indicators of municipal budget with monetary correction and the professionalisation of municipal personnel based on the proportion holding a professional qualification (SINIM, 2022)
- Estimated population of the municipal district (INE, 2022)

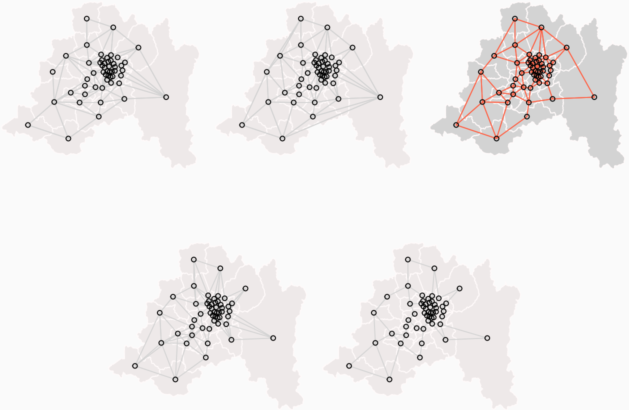
Spatial Autocorrelation and Econometric Strategy

We used **Moran's Index** (Moran's I), which is analogous to the Pearson coefficient for spatial units (Goodchild, 2008). We used one variant **under randomisation** and another with **Markov chain Monte Carlo** (MCMC) simulations for cross-validation.

Values close to zero indicate randomness in the spatial pattern, while values close to 1 and close to -1 indicate perfect correlation and perfect dispersion, respectively.

We worked with vector data from IDE-Chile and SUBDERE (2018, 2020) and spatial matrices based on the **Sphere of Influence (SOI) model**, derived from the Delaunay triangulation (Bivand et al., 2013).

Types of Contiguity Matrices



(i) Queen-style contiguity matrix; (ii) matrix with Delaunay triangulation; (iii) matrix with SOI model, highlighted in colour; (iv) matrix based on neighbours by distance with $k = 4$; and (v) matrix based on neighbours by distance with $k = 2$.

Econometric Strategy

We then used **OLS models**. Our baseline model considers *i-th* municipalities ($n = 345$) and regresses our index $Y_i = \text{EOGi}_{[i]}$ on the number of fixed Internet connections $X_{1[i]}$. As FE, we then incorporated the municipal district's estimated population and population density, before also incorporating the municipal district's rate of monetary poverty $X_{2[i]}$ and, finally, each municipal government's own permanent revenues $X_{3[i]}$ and the rate of professionalisation of municipal personnel $X_{4[i]}$. We used some logarithmic transformations.

$$
\begin{aligned}
Y_i = \alpha + \beta_1\, log(X_{1[i]}) + \beta_2 X_{2[i]} + \beta_3\, log(X_{3[i]}) + \beta_4 X_{4[i]} + \gamma_1\, log(pop_i) \\
+ \gamma_2\, log(density_i) + \varepsilon_i
\end{aligned} \tag{2}
$$

Econometric Strategy

With the model's residuals, spatial autocorrelation can be evaluated statistically with Moran's I. If the test is statistically significant at 95% confidence, the residuals are spatially grouped, and it is appropriate to fit spatial econometric models.

The options include **spatial autoregressive (SAR) models** in which the ρW parameter measures the spatial autocorrelation of the dependent variable. Considering our vector of the *j-th* main independent variables ($j = 4$), the equation is as follows, applying the transformation of the vector's variables when necessary:

$$Y_i = \rho W \, Y_i + \alpha + \sum_{j=1}^{4} \beta_j X_{j[i]} + \gamma_1 \, log(pop_i) + \gamma_2 \, log(density_i) + \varepsilon_i \qquad (3)$$

Econometric Strategy

Another option corresponds to **spatial error models (SEM)**, where the parameter $\lambda\, Wu$ measures the spatial dependence of the errors for a latent continuity variable u.

$$Y_i = \alpha + \sum_{j=1}^{4} \beta_j X_{j[i]} + \gamma_1 \, log(pop_i) + \gamma_2 \, log(density_i) + \lambda \, Wu_i + \varepsilon_i \tag{4}$$

Reliability and Robustness Checks

For the MCMC analyses, we performed a **convergence diagnostic of the Markov chains**, specifically the trace and distribution. In the econometric models, we ran multicollinearity tests and, as indicated above, calculated Moran's I with the residuals of each regression to evaluate the conformation of spatial clusters.

In addition, we applied a series of **robustness checks**, alternating the variable of municipal revenues according to tax collection rates and financial dependency using data from SINIM (2022). We also incorporated a binary variable that reflects the existence of a protocol of citizen participation at the local level to carry out additional tests with a variable from the group of political determinants addressed in the literature.

Results

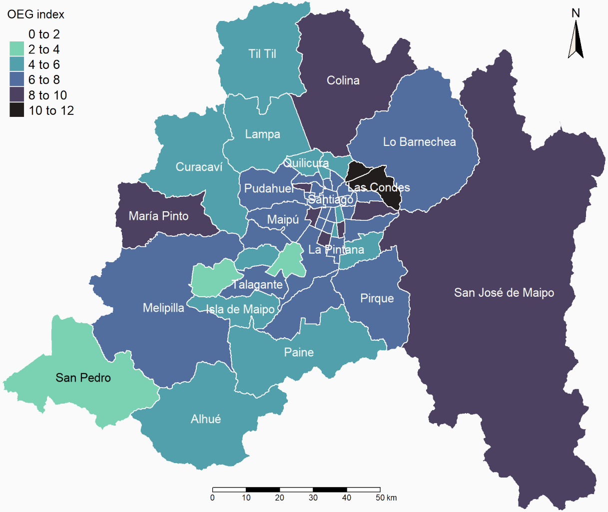
Georeferencing and Spatial Autocorrelation

We detected patterns of **weak spatial dependence at the national level**, with a 95% statistical significance and a Moran's I of 0.183 under randomisation ($p \leq 0.001$) and for the MCMC simulations ($p \leq 0.001$). Only three regions show significant **patterns of autocorrelation** (Tarapacá, Araucanía and Los Lagos Regions).

The Metropolitan Region, the most populous of all Chile's regions, has the country's highest average index: 6.722 out of a maximum possible of 12.5 points. However, the OEGi's spatial distribution does not show significant patterns at the regional level (Moran's I $p = 0.105$, MCMC $p = 0.110$).

Another region that stands out for its high average is the Valparaíso Region, the third most populous, while the areas in the extreme north and south of the country have comparatively lower indices.

Open E-Government Index in the Metropolitan Region



Determinants of Open E-Government at the Local Level

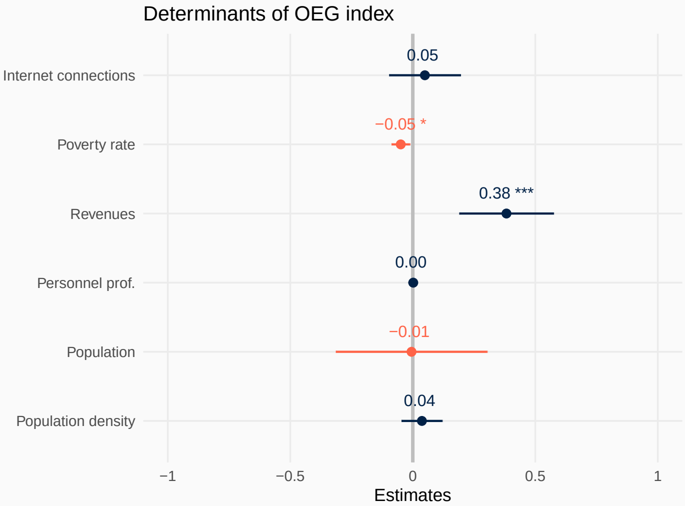
When we incorporated, in model III, the municipal district's monetary poverty rate, the number of **Internet connections ceases to be statistically significant** ($p = 0.307$).

We fitted SAR and SEM models to adequately measure connections' effect on the OEGi.

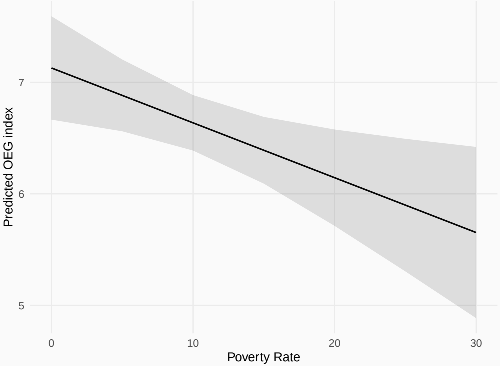
	Model I	Model II	Model III	Model IV	Model V
Internet connections (*log*)	0.285***	0.193***	0.077	0.048	0.049
	(0.027)	(0.073)	(0.075)	(0.074)	(0.074)
Poverty rate			−0.083***	−0.049***	−0.049**
			(0.017)	(0.019)	(0.019)
Revenues (*log*)				0.382***	0.382***
				(0.098)	(0.098)
Personnel professionalisation rate					0.002
					(0.006)
Constant	3,773***	2.827***	3.511***	0.528	0.425
	(0.206)	(0.956)	(0.937)	(1.193)	(1.241)
Population (*log*)	No	Yes	Yes	Yes	Yes
Population density (*log*)	No	Yes	Yes	Yes	Yes
Estimation method	OLS	OLS	OLS	OLS	OLS
VIF	1.324	1.331	1.421	1.486	1.486
B-P/Cook-Weisberg	0.031	0.001	1.364	1.443	1.437
Shapiro-Wilk	0.991**	0.991**	0.995	0.994	0.994
Moran's I	0.081**	0.082**	0.033	0.016	0.018
N	345	345	345	345	345
R^2	0.245	0.249	0.296	0.327	0.327
Adj. R^2	0.242	0.242	0.288	0.317	0.315

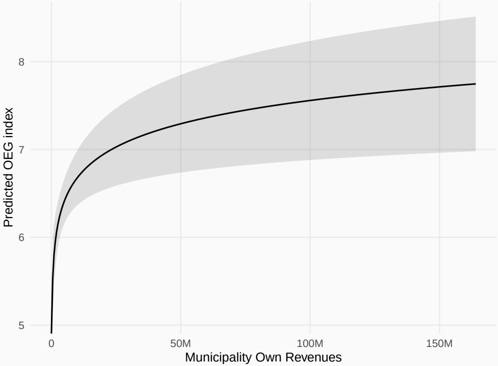
$^{\star}\ p \leq 0.1$; $^{\star\star}\ p \leq 0.05$; $^{\star\star\star}\ p \leq 0.01$

Determinants of Open E-Government at the Local Level



Marginal Effects on Open E-Government at the Local Level in Chile





Robustness Checks

We incorporated a binary variable that measures the existence of **municipal protocols on citizen participation**. None of our tests showed it to be significant.

We also alternated the municipal government's revenues variable with measurements that reflect the level of **local tax collection** and the **municipal government's financial dependence**. Only this last variable was significant, with a negative coefficient at 90% confidence ($p = 0.055$), which is consistent with financial dependence as an aspect of weakness in organisational capacity.

Discussion

Discussion

We present a **novel open e-government index** based on the **e-services model** of Esteves (2005) and **transparency indicators**. At the national level, a slight spatial autocorrelation is detected but, at the subnational level, only the Tarapacá, Araucanía and Los Lagos Regions show clustering.

Our evidence allows us to **accept** the **Socioeconomic Level Hypothesis** and the **Financial Resources Hypothesis** since a municipal district's monetary poverty rate causes decreases in our index while the level of the municipal government's own resources increases it. This is consistent with the literature on open e-government and digital development.

Discussion

On the other hand, we **reject** the **Infrastructure Hypothesis** and the **Administrative Capacity Hypothesis**. The number of fixed Internet connections in a municipal district is significant in the absence of other factors, and the econometric modelling reveals patterns of spatial autocorrelation.

The index we have presented constitutes a **theoretical contribution** that implies dialogue between e-government and open government concepts. It is, moreover, a **methodological and empirical** contribution that can serve as a starting point for future research focusing on problems of non-random selection with observational data at subnational levels.

References

References I

Alcaide-Muñoz, L., López Hernández, A. M., and Caba-Pérez, C. (2014). Public Managers' Perceptions of e-Government Efficiency: A Case Study of Andalusian Municipalities. In Rodríguez-Bolívar, M. P., editor, *Measuring E-government Efficiency*. Springer, New York.

Andrews, R., Boyne, G., O'Toole, L., Meier, K., and Walker, R. M. (2013). Managing Migration? EU Enlargement, Local Government Capacity and Performance in England. *Public Administration*, 91(1):174–194.

Andrews, R. and Entwistle, T. (2015). Public-private partnerships, management capacity and public service efficiency. *Policy & Politics*, 43(2):273–290.

Bivand, R. S., Pebesma, E., and Gómez-Rubio, V. (2013). *Applied Spatial Data Analysis with R*. Springer, New York.

Chapman, S. J. (2017). What's in a website? E-Government Scores and Municipal Characteristics. *Public Administration Quarterly*, 41(2):360–385.

Dias, G. P. and Costa, M. (2013). Significant socio-economic factors for local e-government development in Portugal. *Electronic Government, An International Journal*, 10(3/4):284–309.

References II

DOS-MDSF and ECLAC (2021). Estimaciones Comunales de Pobreza por ingresos en Chile Mediante Métodos de Estimación en Áreas Pequeñas. Working Paper, División Observatorio Social del Ministerio de Desarrollo Social y Familia (DOS-MDSF, Social Observatory Division of the Ministry of Social Development and the Family), Gobierno de Chile and UN Economic Commission for Latin America and the Caribbean (ECLAC).

Esteves, J. (2005). Análisis del desarrollo del gobierno electrónico municipal en España. Working Paper WPE05-32, IE - Reinventing Higher Education. IE Working Paper.

Fath-Allah, A., Cheikhi, L., Idri, A., and Al-Qutaish, R. (2017). A Best Practice Based E-Government Portals' Maturity Model - A Case Study. In *IEEE International Conference on Computer and Information Technology*, Helsinki.

González-Bustamante, B., Carvajal, A., and González, A. (2020). Determinantes del gobierno electrónico en las municipalidades: Evidencia del caso chileno. *Gestión y Política Pública*, XXIX(1):97–129.

Goodchild, M. (2008). Spatial Autocorrelation. In Kemp, K., editor, *Encyclopedia of Geographic Information Science*. SAGE Publications, Thousand Oaks.

References III

IDE-Chile and SUBDERE (2018). Planilla Códigos Únicos Territoriales (CUT). Dataset, Infraestructura de Datos Geoespaciales (IDE-Chile, Infrastructure of Geospatial Data of Chile), Chile and Subsecretaría de Desarrollo Regional y Administrativo (SUBDERE, Undersecretariat for Regional Development), Gobierno de Chile. Available at https://www.ide.cl.

IDE-Chile and SUBDERE (2020). División Política Administrativa 2020. Dataset, Infraestructura de Datos Geoespaciales (IDE-Chile, Infrastructure of Geospatial Data of Chile), Chile and Subsecretaría de Desarrollo Regional y Administrativo (SUBDERE, Undersecretariat for Regional Development), Gobierno de Chile. Available at https://www.ide.cl.

INE (2022). Proyecciones de Población 2002-2020. Dataset, Instituto Nacional de Estadísticas (INE, National Institute of Statistics), Chile.

Lowatcharin, G. and Menifield, C. E. (2015). Determinants of Internet-enabled Transparency at the Local Level. *State and Local Government Review*, 47(2):102–115.

Maciel, G. G., Gomes, H., and Dias, G. P. (2016). Assessing and explaining local e-government maturity in the Iberoamerican community. *Journal of Information Systems Engineering & Management*, 1(2):91–109.

References IV

Manoharan, A. (2013a). A Study of the Determinants of County E-Government in the United States. *The American Review of Public Administration*, 43(2):159–178.

Manoharan, A. (2013b). A Three Dimensional Assessment of U.S. County e-Government. *State and Local Government Review*, 45(3):153–162.

Norris, D. F. and Moon, M. J. (2005). Advancing E-Government at the Grassroots: Tortoise or Hare? *Public Administration Review*, 65(1):64–75.

Puron-Cid, G. and Rodríguez-Bolívar, M. P. (2018). The effects of contextual factors into different features of financial transparency at the municipal level. *Government Information Quarterly*, 35(1):135–150.

Sicáková-Beblavá, E., Kollárik, M., and Sloboda, M. (2016). Exploring the determinants of transparency of Slovak municipalities. *Network of Institutes and Schools of Public Administration in Central and Eastern Europe. The NISPAcee Journal of Public Administration and Policy*, 9(2):121–145.

References V

SINIM (2022). Sistema Nacional de Información Municipal (SINIM). Dataset, Subsecretaría de Desarrollo Regional y Administrativo (SUBDERE, Undersecretariat for Regional Development), Gobierno de Chile. Available at http://datos.sinim.gov.cl.

SUBTEL (2022). Estadísticas servicio de acceso a Internet fija: Conexiones fijas por región y comuna. Dataset, Subsecretaría de Telecomunicaciones (SUBTEL, Undersecretariat for Telecommunications), Gobierno de Chile.

Tejedo-Romero, F. and Ferraz Esteves de Araujo, J. F. (2018). Determinants of Local Governments' Transparency in Times of Crisis: Evidence From Municipality-Level Panel Data. *Administration & Society*, 50(4):527–554.

Tejedo-Romero, F., Ferraz Esteves de Araujo, J. F., Tejada, A., and Ramírez, Y. (2022). E-government mechanisms to enhance the participation of citizens and society: Exploratory analysis through the dimension of municipalities. *Technology in Society*, 70:101978.

Thank you very much!

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